a gun, yet it would take more than a million years for the Sun and his retinue to traverse the distance between us and the stars of that constellation. Accurate instruments prove that the stars toward which we are moving in Hercules are seemingly spreading apart. The problem is like that of a traveler who sees the objects ahead of him becoming apparently wider apart, while of those left behind the reverse is true.

Bessel selected 61 Cygni for an attempt at measurement of distance, because of its large proper motion. Many stars are found to be in motion. The motion seems to be slow, but this appearance is due to their immense distance. It is in reality very rapid, as would be manifest were they near enough to our point of observation. Observations with the spectroscope have comfirmed this view, proving that some stars are moving toward the Earth and others receding. Others, like Sirius, are receding for a period and then approaching. This motion directly in our line of vision could not have been detected by other instruments.

With the meridian circle it was found that Sirius had changed his position 131 seconds in a century. It was also noted that the movement was sometimes less and sometimes more than its mean value. From these irregularities it was calculated that there must be a secondary body revolving around Sirius in a period of about fifty years. The attraction of such a body would account for the disturbance. Some years later the celebrated American telescope-makers, Alvan Clark and Sons, when testing a new eighteen inch object-glass, discovered the companion star. The companion, by an ingenious method, has been found to be half as heavy as Sirius, some seven times as heavy as our sun ; but it is very dim, Sirius being 5,000 times as bright. Here we have a great star performing

the part of a sun for at least one important secondary body which seems to be on the border line between suns and planets.

The variations of Algol are only fully explained by supposing a great dark planet to revolve around him, making a transit across his face at each revolution. In fact this has been proven to be the true explanation. Thus we have arguments stronger than those furnished by analogy, that stars are suns and the centers of planetary systems.

However incomprehensible the number of luminous bodies in the sidereal heavens may be, it must be far exceeded by the number of those that shine only by reflected light. Even in the region of space within reach of the telescope the visible bodies are not a moiety of the majestic aggregate. And there is not in the whole one world, or one granule, in a condition of absolute rest.

We see planets and suns revolving in elliptical orbits, others so far away that we can only determine the direction of their motions, and still others so remote that we are left to infer that they are subject to the same laws of attraction and motion as are those we know.

Calculations as to the weight of certain binary stars, based on their perturbations, indicate that the stars differ in density, as they most certainly do in distance, velocity, size, distribution, color and luminosity. Spectrum-analysis, while indicating the uniformity of the primary material of the Universe, conclusively proves the different conditions and stages of evolution contemporaneously present. Comparatively few bodies have at any fixed times, reached exactly the same stage of development.

Meteoritic, cometary and nebulous matter in the cold regions of stellar space, in widely separated granules, must necessarily be and remain at a very low tempera-

ture if left undisturbed. The particles cool off rapidly, being too small to retain heat for any considerable length of time. But they are all in motion singly or in swarms. They are drawn hither and thither in innumerable collisions. The excitation of heat, and other forms of energy, results in condensation. Nebulæ are formed. The process goes on with increased energy as the distance between the granules decreases, and as the mass is augmented by accessions from a constantly increasing distance. Stars are formed. The process of condensation continues, and the temperature is increased as long as the gain by activity exceeds the loss by radiation. This point is finally passed and the stored energy begins to be lost. After many millions of years the cooling bodies become dark like the Earth.

It follows that the stars would divide into two classes, one, the first in the order of evolution, increasing in temperature ; the other decreasing. Spectrum-analysis so affirms.

Although the fact of the natual evolution of the stars from primary matter could not possibly have been refuted, yet, the timely elucidations and proofs contained in the *Meteoritic Hypothesis* of Sir J. Norman Lockyer, the eminent English astronomer, come with much the same convincing force as did the *Origin of Species* from the pen of Charles Darwin. Astronomy and biology have joined hands.

Lockyer arrives, (among others that are of too technical a nature to be quoted here,) at the following general conclusions :

" All self-luminous bodies in the celestial spaces are composed either of swarms of meteorites or of masses of meteoric vapor produced by heat. The heat is brought about by the condensation of meteor-swarms due to

gravity, the vapor being finally condensed into a solid globe."

"The existing distinction between stars, comets, and nebulæ rests on no physical basis."

"Stars, the temperatures of which are increasing, do not resemble the sun, but consist chiefly of discrete meteoric particles."

"In a single swarm of sufficient magnitude, the ordinary processes of evolution will in time produce successively the luminous phenomena," found in all the seven groups into which he divides the stars.

"The colors of stars follow in orderly sequence through the different groups."

"Double and multiple stars have condensed from double or multiple nebulæ."

"All regular variability in the light of cosmical bodies is caused by the revolution of one swarm or body around another (or their common center of gravity). The revolution of a secondary swarm is an ellipse, and the maximum occurs at periastron ; in the case of condensed bodies the minimum is produced by the secondary eclipsing the light of the primary."

Inconsiderable bodies are in frequent collision. It is therefore not improbable that larger ones occasionally collide, for they are governed by the same laws of motion. The collision of two large bodies, moving with great velocity, developing heat sufficient to reduce both to vapor, would necessarily be followed by a reconcentration, with all the long train of phenomena that naturally follows.

The culmination of the form of energy producing the phenomena and sensation called light is reached in the early middle life of the fixed star, and the highest temperature about the same time. It seems each form of

force reaches a period of its own to which it is adapted ; or, to reverse the proposition, when the conditions arrive, the energy assumes the form adapted to them. In other words, matter under different conditions and different degrees of excitation, produces by its inherent potencies correspondingly different sensible results.

Then all the different forms of energy simply and only indicate the various changes going on in the re-adjustment of matter. The life history of a single cosmical body that has entirely cooled off, and returned to cosmical dust, is the type of the universal race of worlds, including any and all manifestations of energy during the life period, from gravitation to the highest intellectual processes. Force, whether vital or other, is a property of matter. The time, degree and character of the evolution of the material determines the kind of force manifested.

The history of the nebulæ and stars proves conclusively that matter, so far from being dead and waiting for some forming power to set it in motion, is eternally teeming with immeasurable energy. An energy so vast and so intense is yet orderly in sequence, forever following the law of cause and effect, along all the branches and ramifications of moving matter.

When we approach a comprehension of the real magnitude and nature of the starry abyss, and begin to get a glimpse of its real significance, we are struck dumb with astonishment at the recollection of the puerile and absurd theories that have enchained the intellect of mankind through all the centuries.

How strange to think that men, comparatively molecular parasites, should assume that all things were made for them, and war upon and slay each other to maintain their "favorite phantoms!" Strangest of all is the fact

that, even up to the present day, many of the crude absurdities are faithfully and sincerely believed in, after their utter falsity has been conclusively demonstrated by countless facts and logical deductions, accumulated by scientific investigation.

Saddest of all, myriads of people still voluntarily court poverty and dire distress, that great and powerful institutions may be equipped and maintained to perpetuate error under the guise of truth. They display anxiety to ignore the truth, and go out of their way to denounce and ostracise those who, without hope of reward, and in spite of refined persecution, endeavor to guide their faltering steps aright.

Fear, crouching in a quagmire of bare possibility that things may turn out in a supernatural way, attempts to pull down the proud figure of Truth, standing on the solid rock of scientific and mathematical deduction through the law of probabilities.

The real question is not what possibly may be, but rather, what in all probability, is true. One proposition appeals to our superstitious fears, born of ignorance; the other to reason and common sense,—founded on observation and experience.

CHAPTER VIII.

THE SOLAR SYSTEM.

OUR sun is one among the smaller stars belonging to the great, irregularly shaped cluster we call the Milky Way. Along the Milky Way the stars seem crowded in many places, but this appearance is only by reason of their distance from us. Generally speaking, they are probably as far from each other as they are from our Sun. To an observer with a telescope equal to the great Lick refractor, and located on a planet belonging to one of the more remote star clusters, the Milky Way would be barely resolvable into minute points. Among them our sun would remain indistinguishable. To that astronomer the existence of the Earth and her sister planets could only be inferred from analogy. Man, the monad, who has in his ignorance imagined himself the principal object of creation, or a thousand races such as his, would count for naught.

In the preceding chapters we have attempted to gain something of an idea of the processes of sun formation. There is every reason to believe that our Sun is no exception to the rule, in its orderly evolution from the nebulous to its present state. Long after it had become a luminous nebulosity ; it must have filled the space now within the orbit of the farthest planet of our system, and extended millions of miles beyond.

As we return from the sidereal heavens and re-enter our own system, and obtain a nearer view of the methods of nature, the evidence goes to strengthen the nebular hypothesis. The same natural laws have governed here as elsewhere, and the general likeness is maintained. At the same time varying results arising from different conditions are manifest.

Whether our nebulous mass was of meteoritic, or of a gaseous nature, or a combination of the two, or which form of material succeeded the other we do not now consider necessary to discuss. In any case the Sun and planets are here, and in such form, and under such conditions as are fully and satisfactorily explained by natural evolution. It has often been the case that biassed, zealous adherents of a waning faith have wasted their energies in refined hair-splitting, and in raising small distinctions where there were no real differences. This also serves their purpose of distracting the attention of the unwary from the main questions at issue.

There are numerous variations in cloud formation, and in cell division, and in the reproduction of individual plants and animals, as there doubtless are in the initiative and evolution of worlds. The essential truths may be and often are obscured by theological or partisan fog, but they ultimately emerge with renewed splendor in the rays of the surely rising sun of Science.

When the released atoms, molecules, granules, particles, meteorites, etc., had resumed activity sufficient to become luminous, and to re-aggregate, subject to the perturbing influences of a variety of active surrounding stellar masses, there must have been inequalities in the first aggregations. The action of gravitation increased these tendencies, and with collisions, chemical, and electrical action, currents were produced, and rotation

around a common center of gravity became established.

Increased activity led to increased heat and motion. As the rotation became rapid the nebulous mass became round and flattened. External bodies were attracted, and while the mass was yet rare, the planets may have formed in aggregated nebulous masses as indicated by the present appearance of the Canis Venatica nebula. In this case they may have all, or nearly all of them, formed at about the same period. There are some points in the solar system that seem to favor this view. There are a few others which will be considered later, that would indicate that the planets, or some of them, might have been left behind in the form of rings, as in the process of condensation the central mass shrank away from the outside rim.

The period of time required for the formation and final condensation of such planetary rings, in all probability must have been great.

Matter remote from the center of attraction would obey the centrifugal force and concentrate along the outer margin of the revolving mass.

In considering the elements of the solar system, I will begin with the great central luminary from which it derives its name.

The Sun, measured by the accurate methods used by modern astronomers, is distant from the Earth, 92,700,000 miles, and is 865,000 miles in diameter. His density as compared with the Earth is 0.25, and he rotates on his axis in a period between 25 and 26 days. His mass is 331,000 times greater than that of the Earth, and his volume 1,310,000 times greater ; gravity at the surface 27.65 times greater.

A million worlds the size of the Earth would not to-

gether make a mass equal to that of the Sun, and 300,000 would not weigh as much. Using a large orange to represent the Sun, the earth comparatively would be smaller than a mustard seed.

The temperature of the Sun is higher than any we can artificially produce, and is estimated at 14,432 degrees F. Substances which on the Earth are solid are known by the spectroscope to be there in a state of luminous vapor, as in other fixed stars. The process of cooling has reached such a point that over thirty-five elements have been recognized in the Sun ; including such well-known elements as calcium, iron, hydrogen, sodium, nickel, magnesium, cobalt, silicon, aluminum, barium, carbon, copper, zinc, silver, tin, lead, and potassium.

To the unaided eye the Sun appears to be a flat circle, but when its magnified image is projected upon a screen, or examined through the colored sun-glass of the telescope, its globular form is unmistakably recognized.

It is seldom entirely free from spots. They appear black, as constrasted with the generally bright surface. These spots are found to steadily move across the face of the luminary, proving that he rotates on his axis, and in the same direction that his planets move around him in their orbits. The same spots, after about thirteen days reappear on the other edge of the Sun. The apparent narrowing of the spots toward the margins of the disk, due to the obliquity of the line of vision, also proves the globular shape of the Sun. The spots may last through several rotations, but they are never permanent. Their changes are often quite rapid in both shape and size. They generally form irregular groups.

The discovery of sun-spots had to be combated, of course. The strange objection was made that the observation scould not be correct because the Sun was made too

perfect to have blemishes. However, we no longer consider the dark spots as blemishes, but rather as evidences of wholesome activity.

A well-developed spot shows a dark nucleus within the umbra and a margin of a much lighter shade surrounding the umbra, called the penumbra. In some there are several umbræ for one penumbra. The spots are generally confined to two zones, one between ten and thirty degrees north, the other the same distance south; they are rarely seen at the Sun's equator, or higher than forty degrees latitude.

Spots show flame like, and at times cyclonic characteristics. They are often of enormous size; many times the diameter of the Earth. They are believed to be similar to storms, causing openings in the luminous envelope, enabling us to look down into the lower and less luminous layers of heavier vapors. This idea seems to be in a measure corroborated by the fact that the spots have a periodical variation corresponding with the magnetic variation of the Earth. The maximum and minimum periods of their variation also correspond with the number of auroral displays, and with the distance of Jupiter from the Sun. The period of the greater number of spots occurs once in eleven years.

Sudden outbursts of activity in the Sun have been followed immediately by magnetic storms here, disturbing the magnetic needle and the telegraph,—even to the extent of enabling lines to be worked without batteries.

The spectroscope indicates a downward rush of vapors in some places in sun-spots, and in other places upward currents. In some cases the velocities of these currents have been measured by its use.

The telescope shows a granular appearance of the general surface of the Sun, and bright streaks called

faculæ near centers of disturbance. Tongues of glowing gas, seen projecting from the surface when the Sun is totally eclipsed, are perhaps profile views of the same phenomena.

These prominences are shown by the spectroscope to be great masses of glowing gas, at times thrown up with surprising velocity, and again having a quiescent, cloud-like appearance. They have been seen to extend 25,000 miles, 75,000 miles, or even 300,000 miles above the surface of the photosphere. This direct and visible evidence of solar energy, must ever awaken our wonder and interest. This phase of solar activity has some connection with the auroral displays, and probably is of use to us in unsuspected ways; and this at a distance from the Earth so great that, as has been well said, in case a child's arm were long enough to touch the Sun, the impression would not travel along the nerves fast enough for him to feel the burn unless he lived to be over a hundred years old.

The Sun as we see and measure it, with the naked eye, is called the photosphere,—the sphere of light we have before our eyes. Outside of this, and discernible when the photosphere is hidden at the time of total eclipse, is the chromosphere, an ocean of incandescent gases, of scarlet color, composed in part of hydrogen, and about five miles in depth. Still outside of this seething mass is the corona, the extremely rare external envelope, of vast extent and irregular and changing shape. The principal constituent of the lower portions of the corona is hydrogen. Our sun then, in composition and general characteristics, does not differ from other stars of its class.

Without the light and heat developed by it, neither plant nor animal life could exist on the Earth. If we

take the egotistical view of these facts that it is for us that all this energy is exerted, that it was made for us, we are confronted with overwhelming evidence to the contrary.

Only a very small percentage of the light and heat fall upon the Earth. The radiation is in *all* directions from the Sun, and aside from what is intercepted by our diminutive planet and a few others, is lost in space. In another sense there is no absolute loss, for the effect is felt by all the particles of matter within reach, even to the fixed stars.

Prof. Langley calculates that the Sun sends out enough heat to warm, at the distance of the earth, 2,200,000,000 worlds like ours. This vast volume of heat and light is constantly poured forth, whether there are any human beings to receive and appreciate its benefits or not. It does not matter ; the regular, natural processes go on in their consecutive order.

Not an ounce of energy is ever lost. Passing outward from the Sun, it is arrested and stored in planets, stars, and cosmical dust, again to go through its ever-shifting,—never-ending course.

The cooling off of the Sun is a slow process. The Sun is not in any sense a conflagration. The heat is maintained by the contraction of its mass, and by collisions and friction of molecules and masses near the surface, together with the fall of myriads of meteorites. Heat may also be produced from time to time by chemical combinations taking place on a large scale, when the necessary conditions are reached. It does not seem unreasonable to suppose that the heat may be in part kept up according to the theory advanced by Dr. Siemens, that stellar space is everywhere filled with highly rarified substances, which are attracted inward to the Sun,

are gradually heated as they approach, and finally ignite and produce intense heat at the solar surface. The cooling surface envelopes and helps retain the heat.

The heat generated by contraction alone will be sufficient to maintain approximately the present temperature for millions of years. There has been no appreciable falling off in temperature since records have been kept. If any one in this generation, with his fears abnormally developed by cultivation, feels premonitory chills, let him remember that it is not at all impossible that in time to come some star, escaping from other control may fall to the Sun and replenish his waning powers. There is always room for hope.

Find from the almanac on what days the planet Mercury will reach his greatest elongation from the Sun, and look for him in the early twilight or late dawn as the case may be. It is brighter than a star of the second magnitude, but as it is never more than 29 degrees from the Sun, it can only be seen at times when the conditions are most favorable.

As far as is positively known, Mercury is the planet nearest the Sun. Its average distance from the Sun is 35,550,000 miles. It must be remembered that all the planets move in elliptical orbits, with the Sun in one of the foci; so Mercury's distance from the Sun at perihelion is about 13,000,000 miles less than when at aphelion. Its orbit therefore is a very flat ellipse, and he moves with great velocity, about 109,360 miles an hour. The great eccentricity of its orbit is not its only remarkable feature, for it is inclined to the ecliptic about seven degrees, which is more than that of any of the larger planets.

Its revolution around the Sun is accomplished in 87 days, 16 hours, 49 minutes and 30 seconds. Its diameter

is usually given at over 3,000 miles, but Prof. Barnard, with the fine definition and ample magnifying power of the Lick telescope, makes the diameter two thousand seven hundred and eighty-one and three-quarter miles. Its density, the Earth being one, is 2.23.

It has been supposed that Mercury rotates on its axis in a little over 24 hours. A recent observer thinks its periods of rotation and revolution coincide, as is the case with our moon. This is, however, as yet altogether doubtful, for the best telescopes have failed to show on its surface, markings sufficiently unchangeable and distinct to warrant definite conclusions. Its nearness to the Sun, and to the horizon, and the rapidity of its orbital motion, make it a difficult object to study.

Its distance from our planet varies greatly, because its orbit lies inside the orbit of the Earth. When it is in that part of its orbit between the Earth and Sun, it is nearer by the whole diameter of its orbit than when it is beyond the Sun. As it, like the other planets and the Moon, shines only by reflecting the light of the Sun, it follows that when this side of the Sun, its illuminated surface would appear to us as a crescent, and when on the other side as gibbous or round. When examined with a telescope this is found to be so, and it presents all the phases of the Moon. It also appears much larger when seen as a crescent. This discovery furnished one of the early proofs of the truth of the Copernican or heliocentric theory of the solar system.

As regards the question of Mercury being an inhabited world there is no direct evidence one way or the other. The case stands much the same as it does with the planet Venus, and in this regard the two bodies may be discussed together. Then we may be better able to understand why the great recent telescopes fail to show

much more on Mercury than did the little instrument of Galileo.

No almanac, or directions are needed to identify the planet Venus. It is the morning and evening star,—the brightest of all the retinue, being visible to the naked eye in the daytime. Its light, sufficient to cast a shadow, is too dazzling in the telescope for distinct observation. Its phases are just out of reach of the naked eye, and yield readily to the lowest magnifying powers. It, like Mercury, has no satellite. It being like Mercury an inferior planet, it is never seen in opposition, in fact it is never more than 48 degrees from the Sun. The limits of its elongation, being much greater than in the case of Mercury, proves that its orbit is also farther from the Sun.

Its greatest distance from the Sun is 67,500,000 miles, least distance 66,600,000, and its mean distance in round numbers 67,000,000. These numbers show its orbit to approach nearly to a circle. The orbit inclines to the ecliptic 3° 23′. Its period of revolution is 224.7 days. Its diameter is 7,660 miles. Its density 0.85 that of the Earth, and its specific gravity 4.81 ; that of the Earth 5.66.

It will be noticed that this planet resembles the Earth quite closely in many important respects. Its rotation is supposed to take place in about the twenty-four hour period, but owing to the difficulty of observation it has not been positively determined. In fact here, as in the case of Mercury, our knowledge remains where the early, inferior telescopes left us, as far as the surface of our neighboring world is concerned. We know its various phases well, from slender crescent to full, but little else has been revealed by telescopes.

Yet, with the exception of the Moon, it is the nearest

body in the heavens. At its closest approach it is only 23,000,000 miles away. As in the case of Mercury, proximity to the Sun, and the low altitude interfere with distinct vision, but in a lesser degree. The great brilliancy of the planet is a serious obstacle. There are less of these difficulties in the day time, and some of the best observations are then obtained.

The insurmountable difficulty lies in the atmosphere of Venus, heavily laden, as it always is, with clouds. It is doubtful if the surface of the planet was ever distinctly seen. Very likely the spots and markings sometimes observed, but always dim and unsatisfactory, are inequalities in the density, or perhaps only in the upper surface, of the clouds. This accounts for the remarkable intensity of the light reflected by the planet. Mercury shows the same characteristics in the telescope. Few observers of these two planets will question the opinions of the younger Herschel regarding Venus, that it is the most difficult of all the planets to define with telescopes. "The intense lustre of its illuminated part dazzles the sight, and exaggerates every imperfection of the telescope ; yet we see clearly that its surface is not mottled over with permanent spots like the Moon ; we notice in it neither mountains nor shadows, but a uniform brightness, in which sometimes we may indeed fancy, or perhaps more than fancy, brighter or obscurer portions, but can seldom or never rest fully satisfied of the fact. We do not see, as in the Moon, the real surface of the planets" (Venus and Mercury) "but only their atmospheres, much loaded with clouds, and which may serve to mitigate the otherwise intense glare of their sunshine."

Observations of the two planets when in transit across the face of the Sun prove conclusively that they each possess an atmosphere. The image of either of these

planets as projected on the Sun is seen with wonderful distinctness,—standing out like a solid globe.

It does not necessarily follow that because these two planets are nearer the Sun than is the Earth, the temperature of their surfaces is very much higher than it is here. The distance from the Sun is not all there is to the problem. The hottest day at noon, go up on a mountain, or in a balloon a few miles and it is freezing, although nearer the Sun. The temperature of interplanetary space is estimated to exceed 400 degrees F. below zero. The heat is developed by the rays passing through the atmosphere and impinging upon the solid earth. More come in than go out, and are retained and stored in earth, water and air. Different conditions of atmosphere, etc., would change the effects. Therefore it is not unreasonable to suppose that it may be as cool, or even cooler at the surface on either Mercury or Venus, than it is here on the Earth.

Then, as to size, temperature, density, atmosphere, elements, aqueous vapors, light, in fact everything necessary to develop and support living organisms, we have no evidence that the planets under consideration are in any important respect inferior to our own. Reasoning from analogy, and taking into the account the known properties of the active material of the Universe, we cannot afford to deny the strong probability that Venus is inhabited. Mercury would have been included in the same sentence were we not rather inclined to think from its smaller mass and greater density, that it may have reached a period when life there is approaching the end or has already become extinct.

In the case of Venus, however, it may be legitimately believed that it has not yet passed the meridian of planetary life. To an inhabitant of that world, if he could

catch a glimpse of the starry heavens through rifts in the clouds, our Earth would appear the brightest star in their sky.

To the astronomer of Venus the Earth and Moon would afford most instructive objects of study. Imagine such astronomer, with his observatory located on a high mountain peak, in the upper regions of the clouds, where a few nights in the year would be clear enough for the study of the stars. He reaches the true theory of the solar system, and measures the planets and determines their distances. His attention is especially directed to the brightest star in his sky, the one whose orbit lies next outside of that of Venus, the one having the conspicuous satellite. When this star is at its nearest point, in opposition, it becomes a splendid object. He names it Terra, or Earth, and determines its mean distance from the Sun. 92,800,000 miles, and its diameter 7,918 miles. Its period of revolution around the sun is found to be 365 256 days. He observes spots and markings upon its surface that he correctly concludes are continents, oceans, and mountains. From these he finds the period of its rotation on its axis. He sees the polar snows and the moving clouds. He is convinced that he beholds in it another inhabited world. He reasons that Earth is in every essential a twin of Venus. The astronomers of Venus had long suspected that their planet was a globe, although it had never been circumnavigated. He could no longer doubt.

He descends from the mountain and reports his discoveries. He was denounced as an heretic, tried before an ecclesiastical tribunal, and publicly burned at the stake. His discoveries tended to weaken faith in certain ancient traditions and authorities, and he suffered for it. If he had admitted that Venus and Earth were both flat

and resting on foundations; and that with his telescope he had seen the foundations of Earth, and the crystal scaffolding that held the Sun, Moon, and "stars also," he would have received the honors of Venus and finally a place among the saints.

Those who think this picture overdrawn will please take notice that it might have occurred about three centuries ago, at the time Giordano Bruno was burned at Rome for heresy. Thanks to Science, there has been much progress in the comparatively brief period since then, and the future is full of hope. We can at last afford to look upon the act of the superstitious, but honest, good people of Venus with forgiving charity. They knew not what they did.

The magnified image of the Earth as seen from the exterior planets, Mars and Jupiter, would in a year pass through all the phases we see in Mercury and Venus, and the Earth would be a morning and evening star to them, never setting far away from the Sun. The future astronomers of Jupiter will put Mercury, Venus, The Earth and Mars, the smaller, inferior planets, together in one class. When the degree of intellectual development we have reached shall have been reached there, speculations as to the habitability of the four little wandering stars will be in order.

The Moon is 240,000 miles from the Earth, and its revolution around the Earth is completed in 27 days, 7 hours, 43 minutes and 11.461 seconds. Because of the advance of the Earth in its orbit the lunar month is about two days and five hours longer. The Moon rotates on its own axis in the time it takes to revolve around the Earth, so the same side is always toward us. Its diameter is 2,160 miles; its bulk 1-45 that of the Earth; and its weight is estimated at about 1-80 that of the Earth.

As the Moon is a dark body, reflecting the light of the Sun, in its revolution it will show when in opposition a full, luminous disk ; when in conjunction its dark side will be toward us ; and between it will be partly bright and partly dark, manifesting all the phases from a slender crescent to the full moon. When it passes through the shadow of the Earth it is eclipsed, and when it comes in a straight line between the Earth and Sun we have an eclipse of the Sun.

Its attraction is the principal cause of the tides. By the law of gravitation it attracts the water on the side of the Earth toward itself, causing the waters to rise, and at the same time attracts the Earth away from the water on the farther side causing high water there also. The Sun and the Earth also assist in producing or modifying the tides.

The common belief that the Moon greatly influences the weather, has not been justified by recorded observations.

The spots on the lunar surface, seen with the naked eye and the earlier telescopes, were supposed to be seas and continents and were named accordingly. All grades of telescopes have been patiently, carefully and skillfully used in the study of this the nearest and one of the most interesting of the celestial bodies. As it contains so much less matter than the Earth, according to the nebular hypothesis, if it began at about the same time it should now be much cooler and further along toward the end of world-life. That such is actually the case we have good reasons to believe.

There are many difficulties in the way of using successfully the highest powers of either the telescope or the microscope. Generally, less than 1,000 diameters will be found more satisfactory than a greater number, even with the largest instruments. Magnified 1,000 times with the

most exquisitely constructed telescope, the Moon would still appear no better than it would to the eye alone if 240 miles away. Yet, a small instrument of only two or three inches aperature, bearing well a power of about 100 diameters, will display hundreds of very instructive features. It would be a waste of time to look for goats, or to make any chicken estimates.

The conclusion is forced upon us that the Moon is not inhabited on the side always turned toward the Earth, whatever may be the case with the other hemisphere.

Occultation of stars by the Moon is of frequent occurrence, and their instantaneous extinction is evidence of the absence of atmosphere. If water was present it would form clouds in an atmosphere. If clouds were present our optical means would make them easily visible; but it is not known that any have been seen. Some observers have thought they have seen a slight haziness and some changes of appearance in a few low places, but if any atmosphere exists it is exceedingly rare; and there can be very little if any water. The absence of seas, atmosphere, vapors, storms and wind, leaves the rocks and mountains unworn and angular; and volcanic dust remains as it falls, forming circles around the numerous craters. These constitute, perhaps, the most striking features of the lunar landscape.

When the Moon is full, the light from the Sun falls straight upon it and we look directly at it. No shadows are cast, and we have a good view of the so-named seas, which are really great undulating plains, that may indeed be the dry bottoms of ancient seas. As the satellite passes through its various phases, we have all the advantages of oblique illumination; the dark shadows of the hills and mountains are brought out with wonderful distinctness, and may be readily measured. Computing

the heights of the mountains from the lengths of the shadows is an accurate process. Objects of much interest are named or numbered, and catalogued and mapped. The perfected methods of photography are producing promising results. In the future any changes taking place may be detected with more certainty.

Tycho, the most striking specimen of the lunar crater-mountain, visible to the naked eye at full moon, with a diameter of 54 miles, and a depth of three miles, with a central mountain nearly a mile high, lies in the exceedingly rough region in the southeast quadrant. Not a level spot can be found near it. It is well to remember that the astronomical telescope inverts the image.

Tycho is the center of the largest system of radiating streaks, which are visible at full moon. These rays pass through mountains and valleys alike, and appear like cracks in the hardening, brittle crust, and as if caused by pressure from the interior; the cracks being subsequently filled with matter of a different color. As far as the shape of Tycho is concerned it can be taken as the type of a numerous class.

There are other enclosed plains without any central cone. Of this class, Plato must not be overlooked. It is located in the northeast quadrant, well toward the pole, at the edge of the great plain called Mare Imbrium. The rampart, as may be seen by its shadow within and outside the plain, varies greatly in height, from 4,000 to 9,000 feet. The enclosed plain is about 60 miles in diameter, and very level. Some observers have thought they detected changes taking place in it.

In the same quadrant, toward the equator, lies Copernicus, a crater 56 miles in diameter, its central mountain having 6 peaks. Its ring, like others, is distinctly

terraced, and rises 11,000 feet. It is also, like Tycho, a center of a region of bright streaks.

To the west of Plato are the mountains called the Alps; and just over the line, in the northwest quadrant, is the Great Valley of the Alps, a cleft over 80 miles long and from four to five miles wide, breaking through the mountains in a straight line. It looks as though a great meteor coming from the northwest had struck a glancing blow and stopped before reaching the large plain. About half-way from this region to the equator is a chain of mountains 460 miles long, the lunar Apennines; the highest peak 21,000 feet.

Of course, clefts are numerous, some of them of great length, with unworn edges and reminding one of cracks in glass. There are faults, and wrinkles, and hills and valleys. The whole globe has an old and wrinkled look.

A remarkable object, probably caused by a fault, one side being lower than the other, called the Straight Wall, or The Railway, a straight line, 60 miles long, in the southeast quadrant some distance northeast of Tycho, is well worth the amateur's time to look up.

The highest mountains are the Leibnitz, near the south pole, at the edge of and a little beyond the limb, 30,000 feet above the surface. I have seen them in profile during an eclipse of the Sun. In comparing lunar mountains with ours, allowance must be made for there being no seas on the Moon.

If we accept George Darwin's tidal theory, the rotation of the Moon during its probable period of habitability was much more rapid than at present.

To me there are no more interesting objects on the Moon than those old circular craters that lie partly in the higher land and partly in the plain. In many instances